" ELIMINATION OF REPETITIVE THRUST BEARING FAILURES ON A PROCESS AIR COMPRESSOR"

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THE TEXAS A & M UNIVERSITY SYSTEM

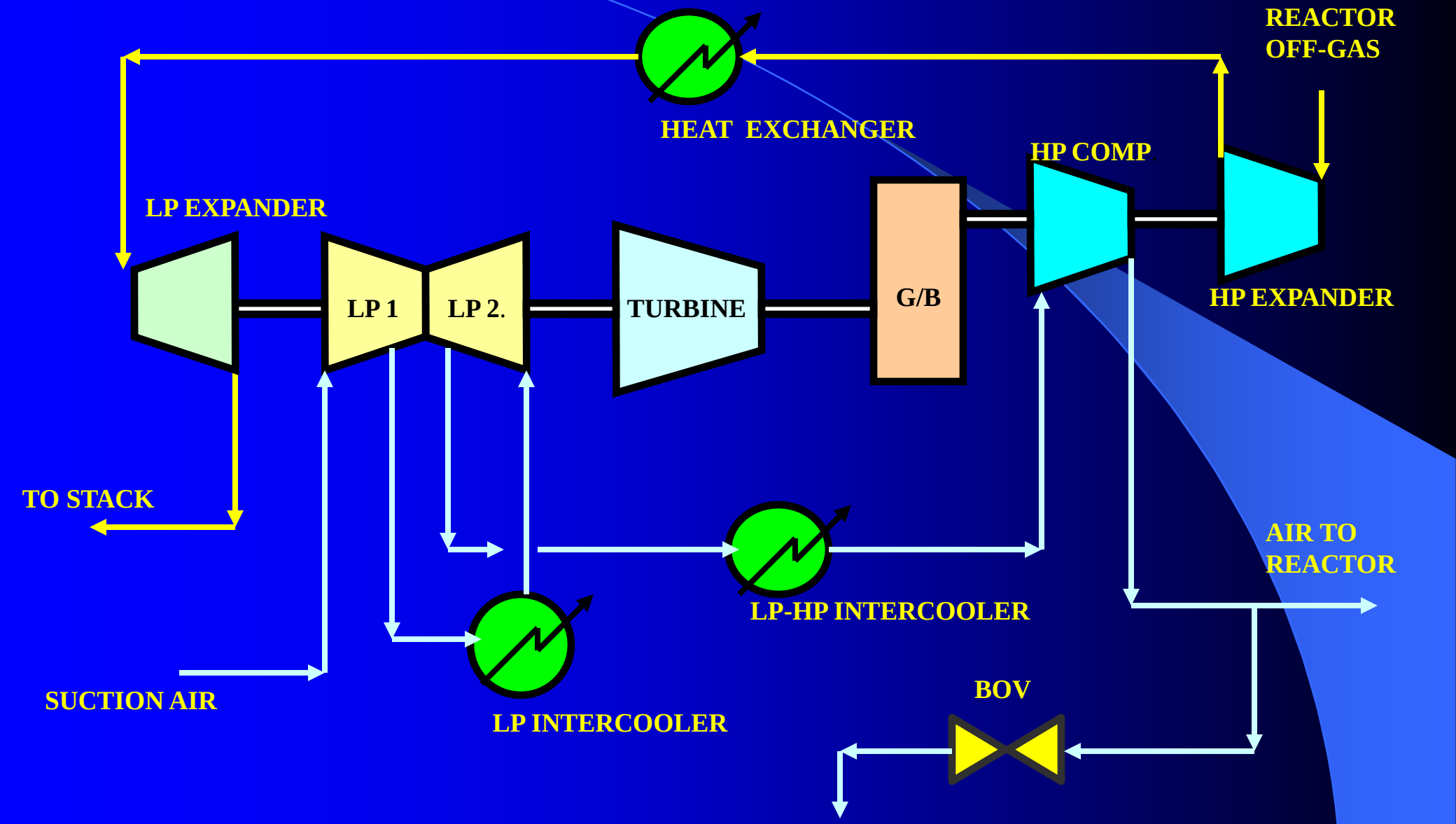
BRIEF DESCRIPTION OF PROBLEM

- Repetitive failure of thrust bearing in a Turbo Driven Process Air Centrifugal Compressor.
- 3 failures in 2004-2005.
- The downtime for replacement of this bearing was amounting to a loss of US $ 88,888 (Rs. 4 million) / failure.

EQUIPMENT UNDER STUDY

- NAME : PROCESS AIR COMPRESSOR.
- SUC. FLOW RATE : 63340 M^3/HR (37280 CFM)
- DISCH. PRESSURE : 25.2 BAR A
- DISCHARGE TEMP : 194^{0}C (381^0 F)
- SPEED : 13,920 RPM
- 1ST / 2ND CRITICAL : 8276 / 17576 RPM
- DESIGN PR. / TEMP. : 27.5 BAR A / 250 ^{0}C (482 ^{0} F)
- DRIVE : TURBINE (CONDENSING TYPE- 16 HP & 6 LP STAGES, RATED / MAX. OUTPUT- 6.6 MW / 8. 9MW)

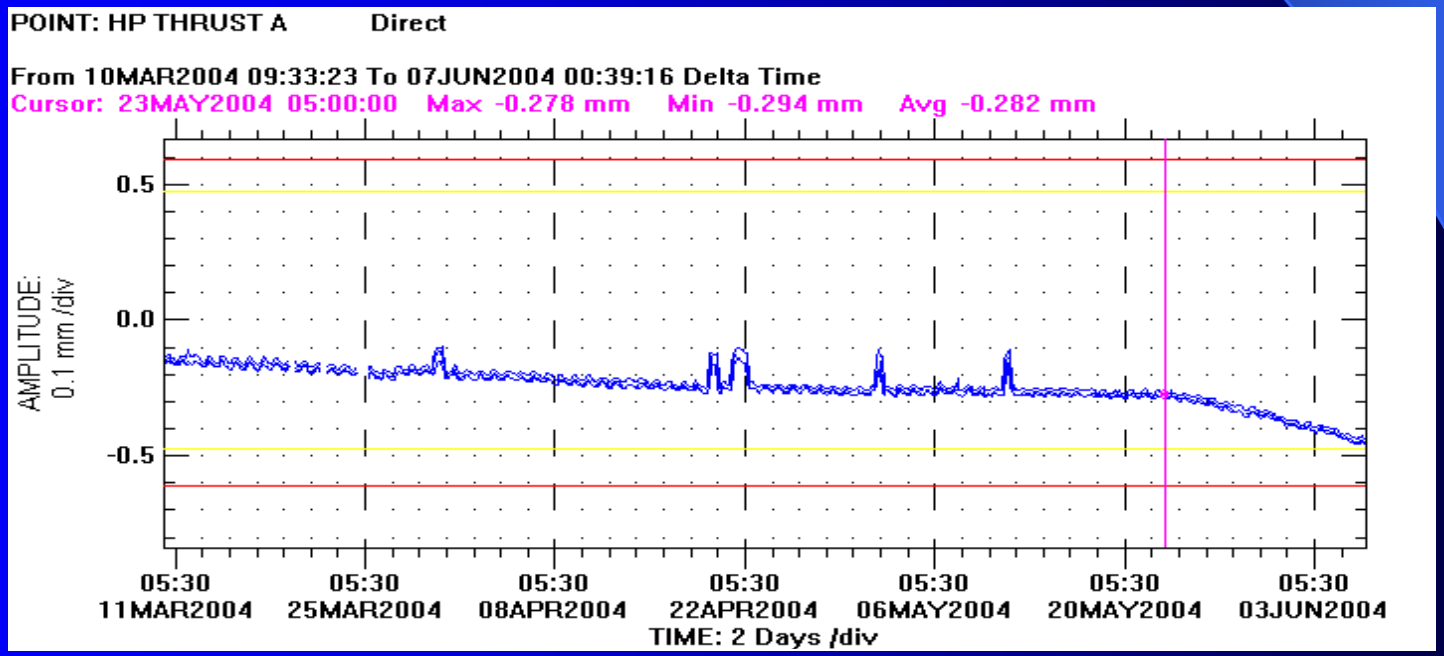
MACHINE TRAIN DIAGRAM



HISTORY

- HP Compressor active side thrust bearing was replaced during the annual shutdown (Jan'2004), as severe pitting was found on its pads .

- 5 months thereafter, increasing trend with a sharp spurt, observed in the axial displacement of the HP compressor.



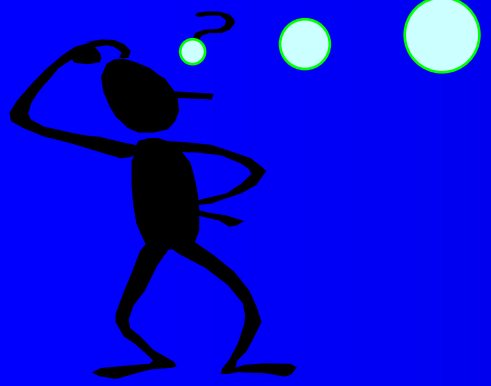
PARAMETER OBSERVATIONS

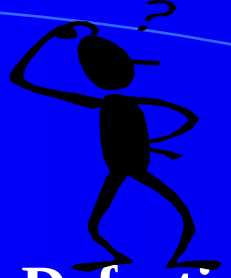
- **No appreciable change in the process parameters such as flow or pressure.**

- **Increase of @ 5- 6 ^{0}C (9 ^{0}F - 10 ^{0}F) in the active side thrust bearing temperature.**

- **Vibrations at the journal bearings normal, with no abnormality in the spectrums & orbit plots.**

WHAT COULD BE PROBABLE CAUSE??





PROBABLE CAUSES OF FAILURE

- Defective bearings ?
  - Ruled out as bearings were OEM supplied.
- Improper lube oil supply ?
  - Ruled out as journal bearing temp. Were normal.
- Faulty shaft grounding ?
  - Visual inspection of the dual carbon shaft grounding brush not possible due to inaccessibility.
  - No current observed in the Earthing terminal wire, when checked with milli- Amp Tong tester.

OBSERVATIONS

Machine was shut down for inspection/ replacement of thrust bearing & grounding brushes . Following observations were made-

- Shaft grounding brushes worn out & jammed in the carrier.

OBERVATIONS

- Uniform wear out & “ Frosting ” marks along with oil varnishing observed on Active Thrust bearing pads .

OBSERVATIONS

- Wear out of **0.35mm (13.77 mils)** observed in the active side pads.
- **No Abnormality or Wear** in the inactive side bearing .

IMMEDIATE ACTIONS TAKEN

- Active side Bearing replaced with new one.
- Brush carrier thoroughly cleaned & brushes made free.
- Axial float adjusted to **0.2 mm (7.87 mils).**
- Machine boxed up and taken in line. **All parameters found normal.**
- Axial displacement recorded to be **- 0.18 mm (-7.08 mils)** { as against **– 0.46mm (-18.11 mils)** at the time of **Shutdown** }
- **1mA** current was measured at earthing terminal.

PROBLEM WITH CARBON BRUSHES

- Carbon Brushes By Design Have Following Disadvantages-

1. Intended for continuous, higher current densities (60-80 amperes per sq.Inch).
2. At low current densities (less than 40 amperes per sq.Inch), they develop non-conducting glaze on the contact surfaces, impairing the ability of the brush to properly function.
3. Brushes "gum-up" in presence of oil and / or dust found in the field and hence require frequent cleaning.
4. Besides the above disadvantages, in this case, even the inspection of the brushes called for an Expensive Machine Downtime.

MECHANISM OF FAILURE

- In condensing turbines the last stages are subjected to saturated steam.
- The brushing effect of the water droplets (condensate) across the blades results in development of an electrostatic charge that builds up on the rotor.
- Charge periodically discharges to the ground through the path of least resistance.
- Dissipation of rotor voltage across an oil film bearing produces microscopic pits, resulting in loss of babbit, giving it a **"Frosted"** appearance. Local overheating due to spark results in **Varnishing** of the oil.

MECHANISM OF FAILURE

- Voltages generated in the turbine rotor are transmitted throughout machine train. Failure can occur on the bearing away from the source of generation.
- Residual magnetism in the rotor can also be a source of generation of stray electric currents. **Since the slow roll readings and vibrations at operating speed were normal , the chances of residual magnetism in the rotor was ruled out.**

Thus this failure was attributed to the following reasons –

- **Design :- Faulty shaft grounding brushes**
- **Supervision :- No regular check to ensure functioning of brushes.**

RECOMMENDATIONS

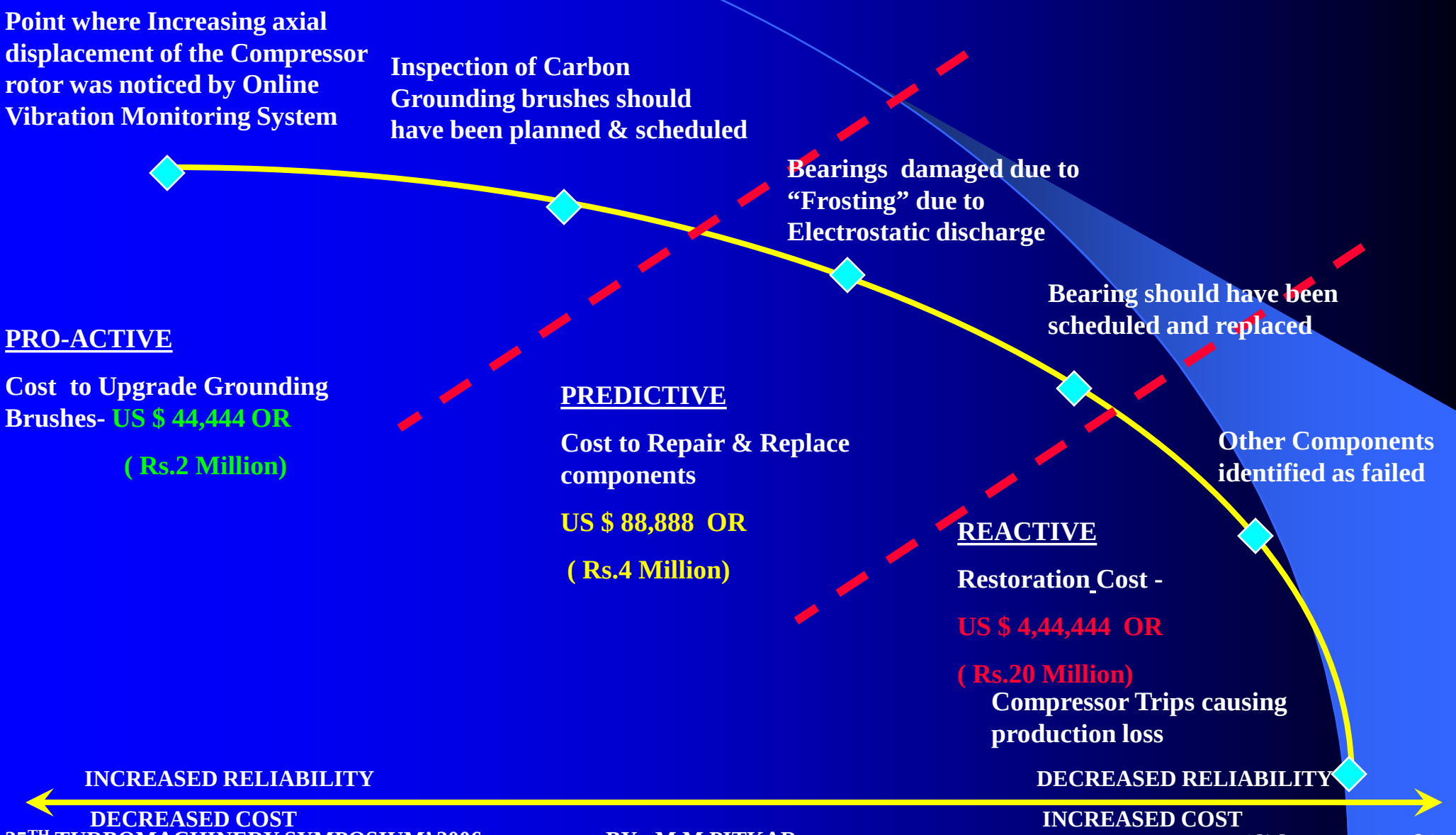
- Replace brushes with improved design,
  - To enable inspection &
  - Replacement without machine stoppage.
- Regular monitoring of shaft grounding current to ensure proper functioning of the brushes.

RELIABLE SOLUTION

- **Bristle Type Brushes By Design Have The Following Advantages-**

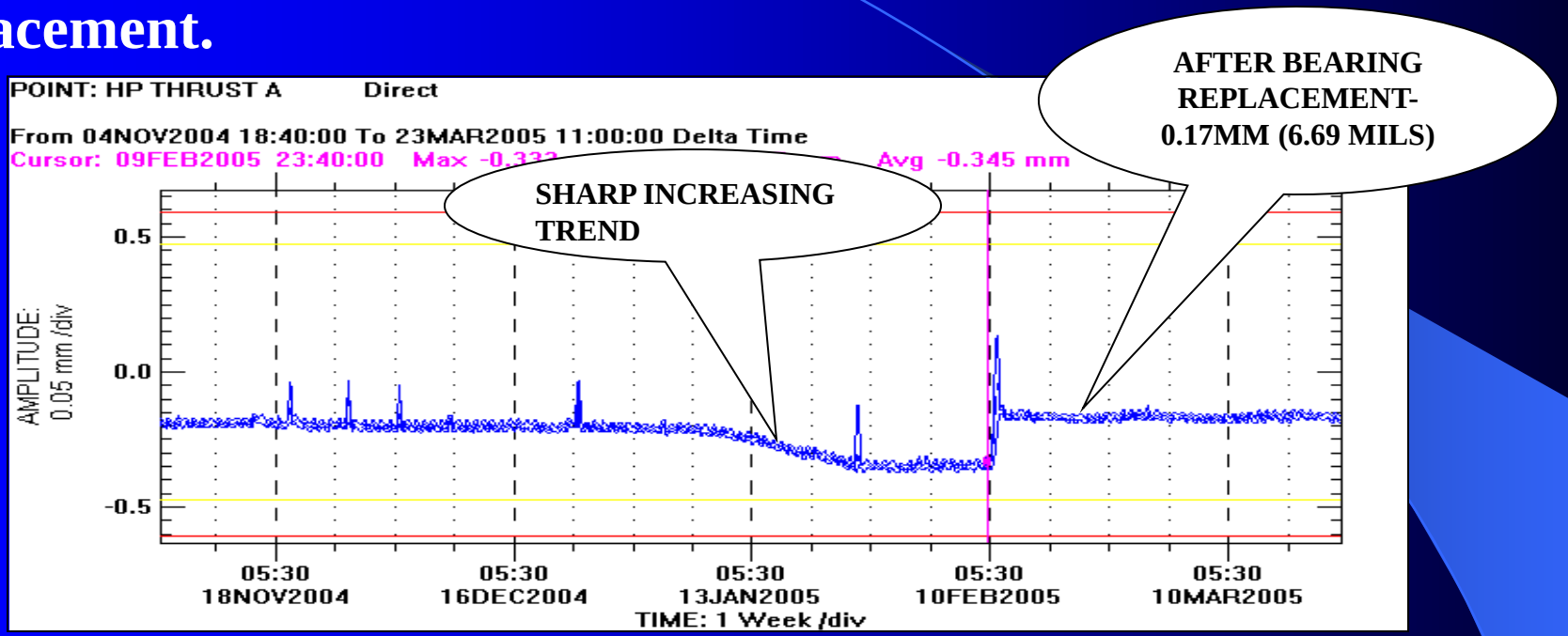
1. **Gold plated, Silver alloy bristle head brushes offer better contact and Very low contact resistance (6 milli-ohm).**
2. **Bristle construction ensures sufficient contact and proper functioning even in presence of oil and/or dust.**
3. **Mounting system has a wear indicator.**
4. **Replacement of brushes with no stoppage of equipment.**
5. **Monitoring system with alarm to indicate malfunctioning of any brush.**

" The Benefits of Reliability to the P-F Curve"



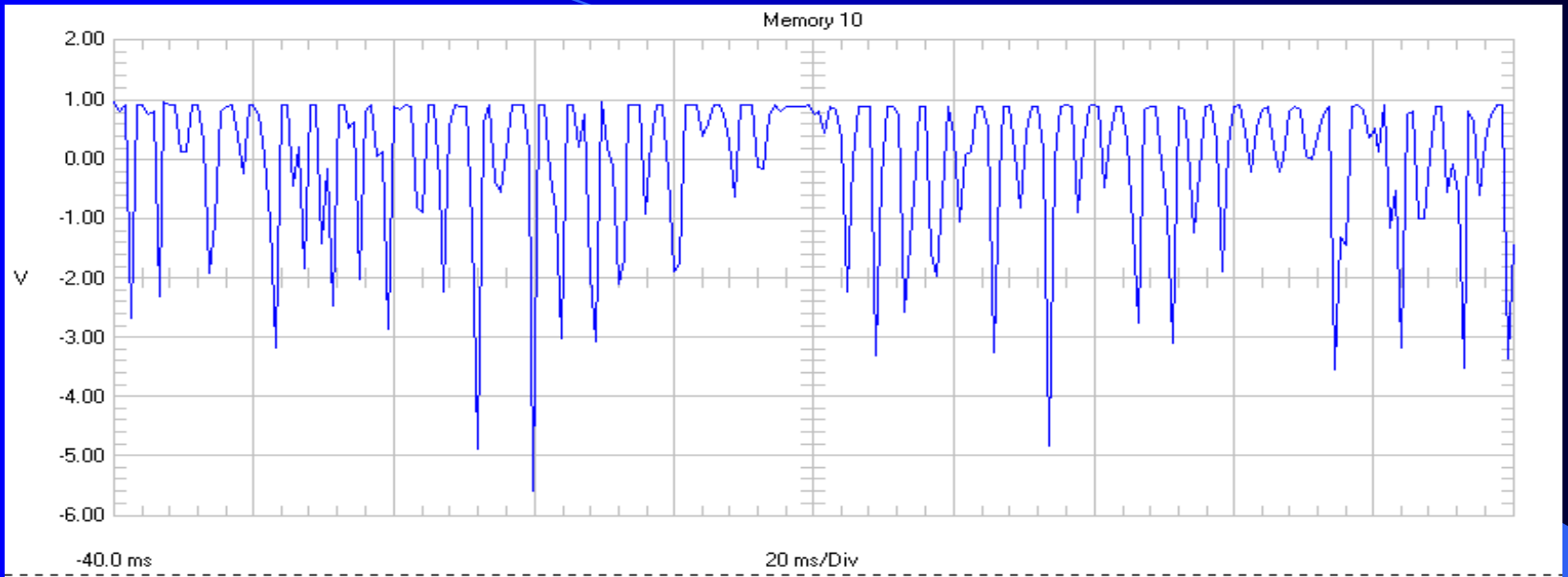
REPETITIVE FAILURE

- Similar increasing trend with a sharp spurt, observed in the axial displacement.



- Observations similar to the earlier failure were made during the planned shutdown .
  - Carbon brushes “gummed-up” or jammed.
  - “Frosting” with pad thickness reduction .

SHAFT VOLTAGE TRACES WITH CARBON BRUSHES

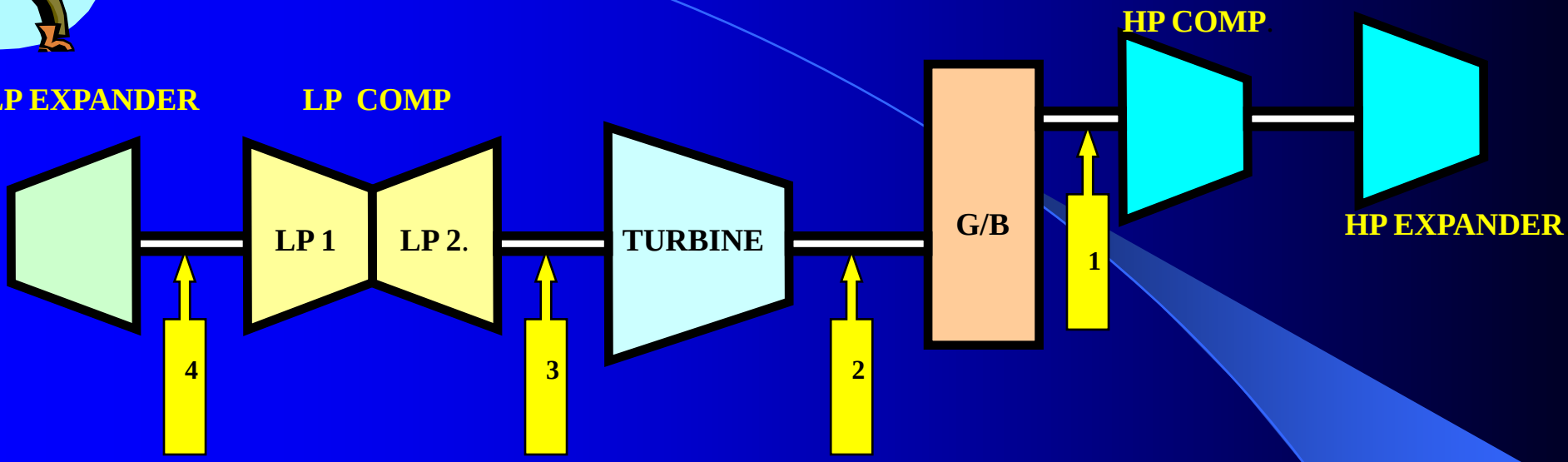


GHH PAC-C113 Comp: Shaft Voltage at the HP side of the compressor with carbon brushes on the shaft.

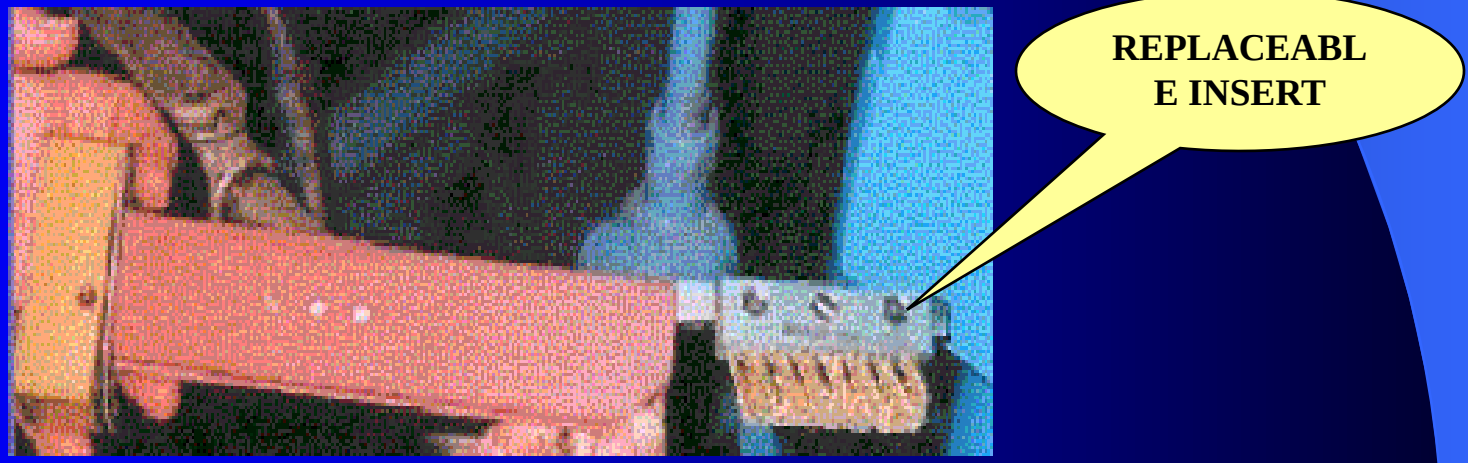
- Traces taken with Flukescope meter & portable gold plated brush, adjacent to the respective carbon brushes.
- Shaft voltage of 6V pk-pk was measured between the HP compressor and gearbox

Carbon brushes were ineffective in reducing potential between shaft and bearings, on that specific shaft, to below 50mV.

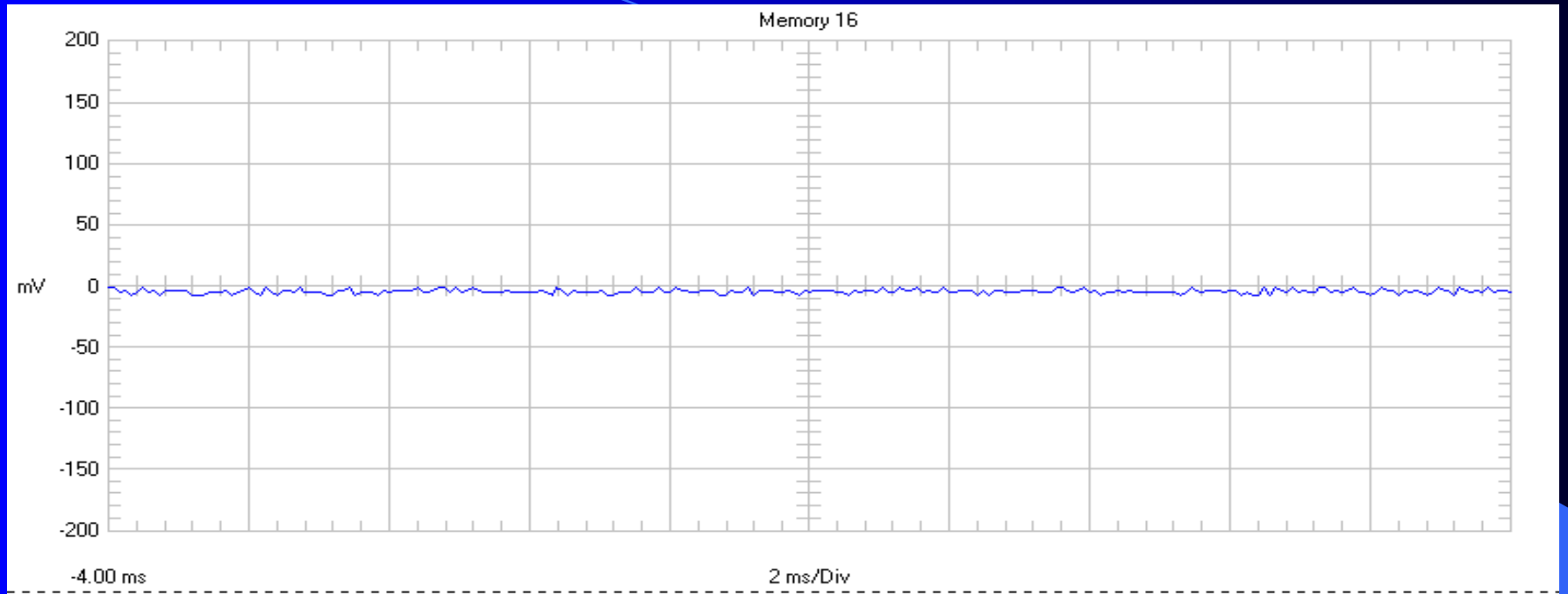
INSTALLATION OF BRUSHES



SILVER + GOLD COMPOSITE BRISTLE TYPE BRUSH



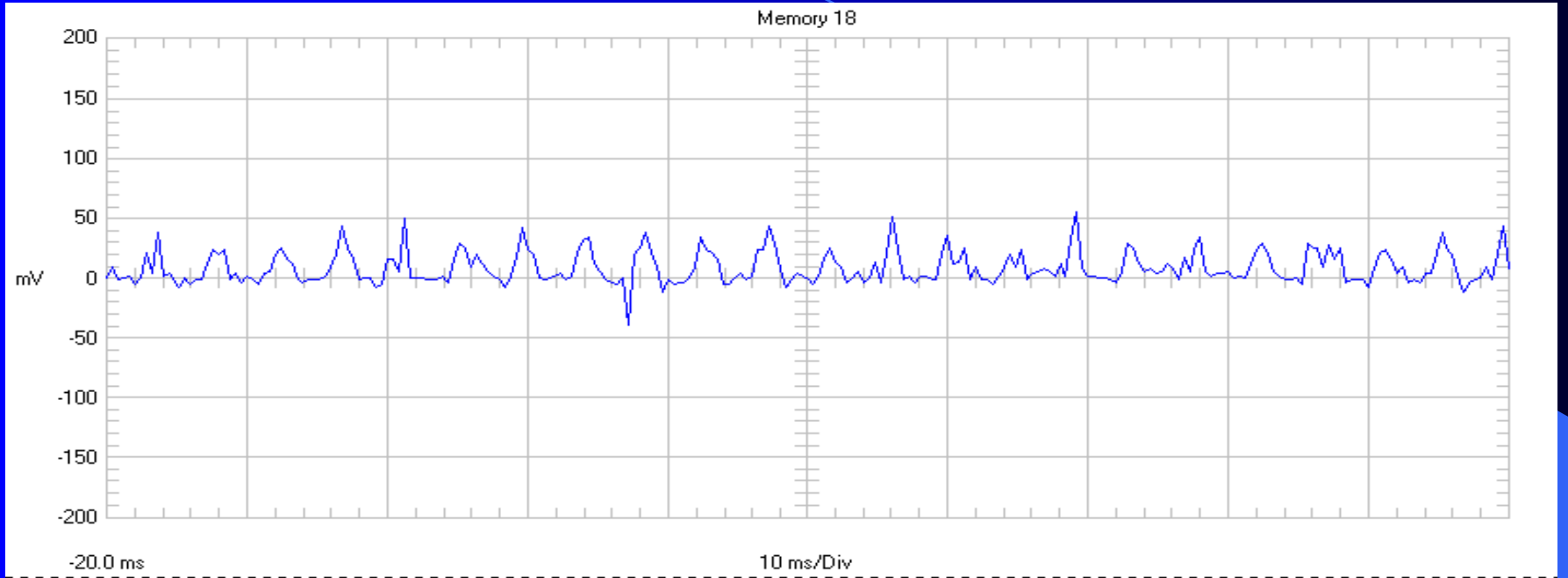
SHAFT VOLTAGE TRACE WITH NEW BRUSHES



Shaft voltage across 5 amp shunt between gearbox and the HP compressor on GHH C113 comp.

- Voltage traces taken across 5A shunts at different brush locations with the brushes connected to the ground to determine the shaft current.
- Shaft voltages dropped to below 50mV with a current flow of approx. 0.2A

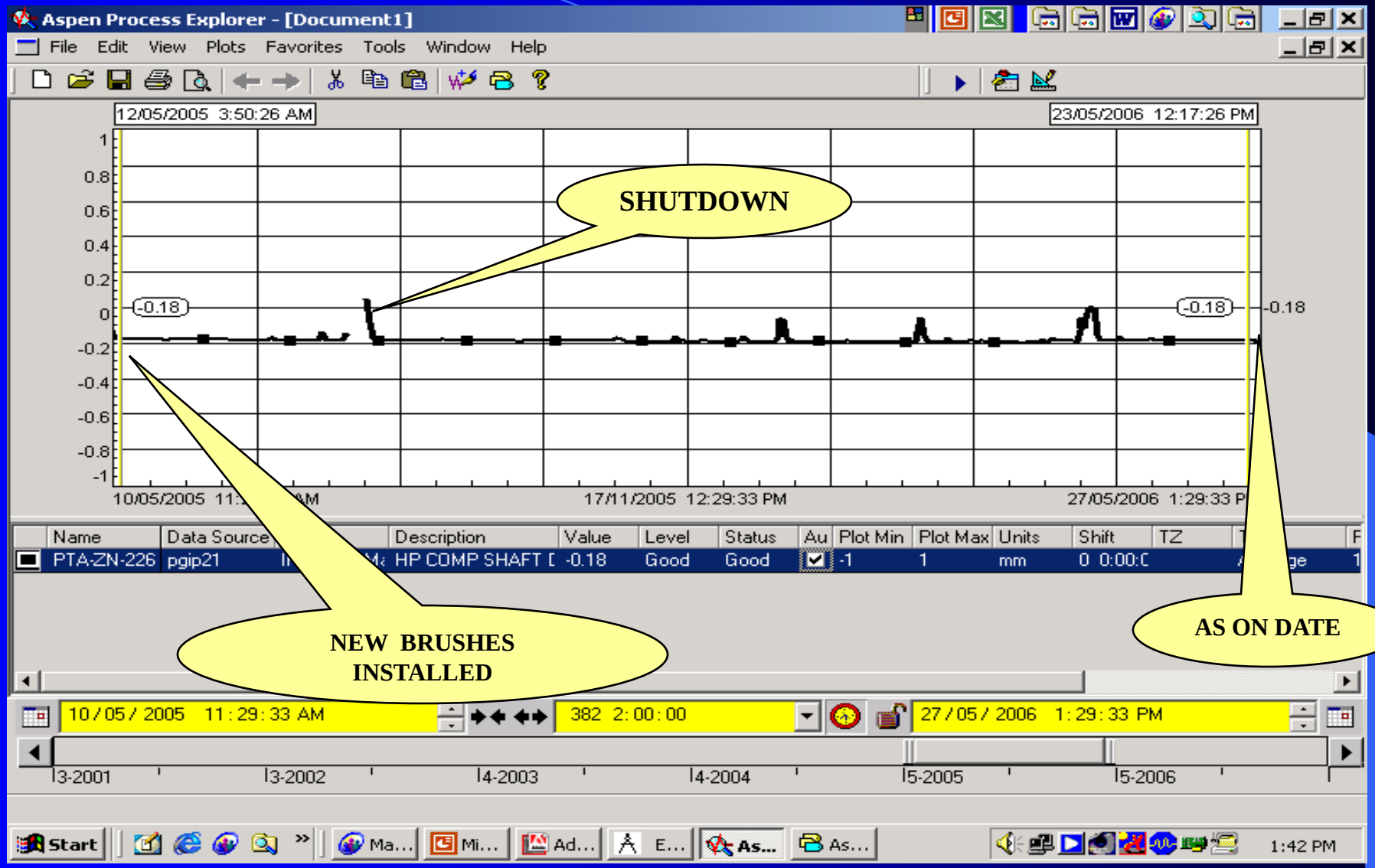
SHAFT VOLTAGE TRACE WITH ONE BRUSH DISCONNECTED

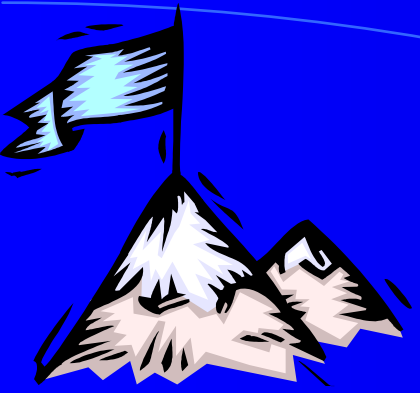


Shaft voltage between the gearbox and the HP compressor on GHH C113 comp with the ground disconnected from the brush.

- Shaft voltage spikes below 50mV were generated, probably due to some residual magnetism.

AXIAL SHAFT DISPLACEMENT TREND





LEARNINGS

1. Electrostatic shaft voltages are possible on machine trains driven by condensing steam turbines. These voltages are controllable by isolation and/or grounding of the rotating assemblies.
2. Electromagnetic shaft voltages appear when rotating magnetic fields are generated by magnetized machine elements and can only be eliminated by degaussing the magnetized parts.

THANK YOU